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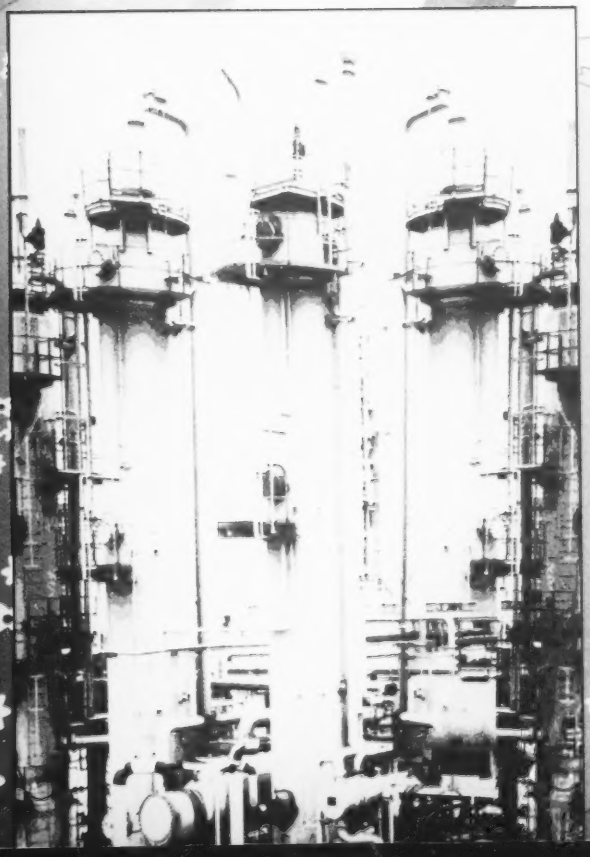
CHEMICAL & ENGINEERING NEWS

C&EN

SEPTEMBER 5, 1994

SCIENTIFIC NEWS FROM THE WASHINGTON ACS NATIONAL MEETING



DESIGN FOR THE ENVIRONMENT

Chemical syntheses that don't pollute

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CHEMICAL & ENGINEERING NEWS

C&EN

SEPTEMBER 5, 1994

NEWS OF THE WEEK

■ Consolidation of the pharmaceutical industry continues with acquisition of Sterling Winthrop by SmithKline Beecham for $2.9 billion and purchase of Zenith Labs by Ivax for $594 million. **Page 4**

■ Combinatorial techniques produce synthetic receptors that bind biological substrates larger than those previously possible with conventional methods. **Page 5**

■ EPA proposes rule defining how it will regulate genetically modified organisms under the Toxic Substances Control Act and issues final rule on field testing of bioengineered microbial pesticides. **Page 5**

■ CD-ROM versions of ACS journals *Biochemistry* and the *Journal of the American Chemical Society* are selling briskly. **Page 6**

■ U.S.-China commercial ties and U.S. chemical exports to China get major boost from mission to China led by Secretary of Commerce. **Page 6**

■ NIH awards a total of $6.2 million to six research groups as part of a multi-million-dollar program to develop innovative therapies to fight HIV infection. **Page 7**

COVER: Design by Amy Hayes

Volume 72, Number 36
CENEAR 72 (36) 1–64
ISSN 0009-2347

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Chemical & Engineering News
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Published by
AMERICAN CHEMICAL SOCIETY
(202) 872-4600; TDD (202) 872-4432
John Kistler Crum, Executive Director
Robert H. Marks, Director, Publications Division

PUBLISHING BOARD: Joseph A. Dixon *(Chairman); Board of Directors Chairman:* Paul H. L. Walter; *President:* Ned D. Heindel; Paul S. Anderson, Richard L. Deming, Paul W. Jennings, Barbara J. Peterson

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Subscription Rates 1994: Printed editions: nonmembers U.S. 1 yr. $115, 2 yr. $207; outside U.S. 1 yr. $152, 2 yr. $281. Air freight rates available on request. Rates above do not apply to nonmember subscribers in Japan, who must enter subscription orders with Maruzen Co. Ltd., 3-10 Nihonbashi 2-chome, Chuo-ku, Tokyo 103, Japan. Tel: (03) 272-7211. Single copies: Current $18. Rates for back issues and volumes are available from Microforms & Back Issues Office, ACS, 1155—16th St., N.W., Washington, D.C. 20036. Back and current issues available on microfilm and microfiche. Rates on request from Microform Program, ACS.

Chemical & Engineering News (ISSN 0009-2347) is published weekly except for the last week in December by the American Chemical Society at 1155—16th St., N.W., Washington, D.C. 20036. Second-class postage paid at Washington, D.C., and additional mailing offices. POSTMASTER: Send address changes to C&EN, Member & Subscriber Services, P.O. Box 3337, Columbus, Ohio 43210. ACS assumes no responsibility for the statements and opinions advanced by the contributors to its publications.

Advertising Management: CENTCOM LTD.
(For list of offices see page 63)
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LETTERS

Impairment versus drug testing

An increasing number of chemists and chemical engineers are being subjected to random drug tests. Initially limited to workers in positions with unique safety concerns, testing is slowly expanding to include other jobs. In 1991, DuPont abandoned plans to test engineering department employees after many of them expressed concern over testing errors, invasion of privacy, and the potential degradation of employee-management trust.

In light of the grave damage to career and reputation that can occur from testing error, participants need to be aware of the myriad routes through which mistakes can occur. C&EN (Aug. 8, page 56) recently noted that poppy seed consumption can lead to the misdiagnosis of heroin use. I have previously reviewed the metabolic and procedural chemistry underlying this and other drug misidentifications (*CHEMTECH*, Sept. 1992, page 523).

In an example from the chemical industry, the urine of a Laporte, Tex., worker incorrectly tested positive for methamphetamine when a National Institute for Drug Abuse (NIDA)-certified testing laboratory misdiagnosed the legal decongestant pseudoephedrine—present in more than 100 over-the-counter medications—as an illicit drug. For months, the innocent employee was treated as a drug abuser. A second false positive has been uncovered involving another employee at the same company.

A pilot at a major U.S. airline lost his job after testing positive for opiates, the source of which was later determined to be aspirin purchased in Canada, which, unknown to him, contained codeine as a legal part of the drug formula (*Aviation Safety*, June 15, 1993, page 6). Following the *Exxon Valdez* oil spill, blood samples drawn from Capt. Hazelwood by the U.S. Coast Guard and placed in 15-mm test tubes with gray stoppers were recorded by Compuchem, a NIDA-certified testing laboratory, as having arrived in 10-mm test tubes with red stoppers. After the laboratory measured a 0.06% blood alcohol level, Hazelwood was indicted. But Compuchem did not inform Hazelwood of the anomaly in the chain-of-custody or of changes to the documentation made five weeks later (*New York Times*, July 28, 1990, page 7). Even sample spiking or data falsification are possible. Workers at one testing laboratory were convicted of fabricating positive drug test results (C&EN, June 29, 1987, page 19).

DuPont-funded studies by the American Association of Clinical Chemistry indicate that a false positive rate of one per 700 urine samples can be achieved by using two testing procedures to enhance accuracy [*Clin. Chem.*, **33**, 1682 (1987); **35**, 891 (1989)], and all NIDA-certified laboratories use such procedures. No peer-reviewed scientific studies have been published indicating that lower error rates are presently attainable.

When safety is an issue, a more informative and more dignified alternative to random drug tests is available—impairment tests. These quick and inexpensive tests provide immediate feedback and can be administered daily to detect impairment by any cause, including fatigue, illness, or drugs. A blue-ribbon panel sponsored by the National Research Council recommends that industry more seriously consider their use in place of random drug tests for workers in safety-sensitive positions ("Under the Influence? Drugs in the American Work Force," National Academy Press, Washington, D.C., 1994). The *Exxon Valdez* oil spill, brought about by the impaired performance due to fatigue of the operator steering the ship, might have been avoided if such tests were in use.

I recently had the opportunity to try out one such test offered by Performance Factors, Oakland, Calif. I was impressed by the speed and simplicity of this computer-controlled hand-eye coordination test. Based on technology developed to study pilot performance under adverse conditions, scientific studies have shown the results to correlate with levels of alcohol and drugs in the blood [*Psychopharmacology*, **85**, 51 (1985)]. Another test analyzing for cognitive skills is offered by Essex, Columbia, Md.

The American Medical Association has provided a thoughtful critique of random drug testing, recommending that impairment testing be used in its place [*J. Am. Med. Assoc.*, **264**, 1039 (1990)]. Their general counsel, David Orentlicher, writes: "In some way, there can be an important symbolic value when a hospital effectively declares zero tolerance for drugs by instituting urine drug testing. However, the symbolism may have unintended effects. While the hospital tells its patients they are receiving the most effective treatments for their diseases, it is employing a less-than-optimal method for detecting physician impairment. . . . Hospitals should be careful not to abandon other

Continued on page 46

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ganisms in different genera. The rule requires persons intending to manufacture, import, or process intergeneric organisms for commercial purposes to file a Microbial Commercial Activity Notice (MCAN) with EPA at least 90 days before undertaking such activity. Introduction of such organisms into the environment for commercial R&D purposes requires 60 days' advance notification.

EPA also proposes to exempt from the MCAN requirement 10 microorganisms commonly used in contained fermentation systems to make specialty chemicals, particularly enzymes. R&D testing of intergeneric microorganisms would be exempt from EPA oversight when tests are conducted in contained structures, such as greenhouses or labs.

The final rule on field testing changes the current requirement of advance notification to EPA for even small field tests of genetically modified microbial pesticides. The new rule, issued under the Federal Insecticide, Fungicide & Rodenticide Act, exempts from the requirement small-scale field tests of organisms in which the genetically induced changes are similar to those that occur in nature.

"We're delighted that the agency has persevered and gotten these rules out," says an Environmental Defense Fund spokeswoman. This "is a big step forward . . . because for the first time EPA will actually have rules covering biotechnology products."

A spokesman for BIO, the Biotechnology Industry Organization, couldn't comment in depth on the proposed rule because he hadn't seen it, but says, "We're happy to have a proposed rule to study and comment on. It's been quite a period of time under development." He points out that EPA has been operating under a 1986 policy statement to regulate biotechnology products. "Clearly, they can do that," he says. "But there are a lot of nuances as to how they implement the policy" that need to be defined by regulation. The rules were published in the Sept. 1 *Federal Register*.

Janice Long

U.S. seeks to boost chemical sales to China

U.S.-China commercial ties and U.S. exports to China, including chemical exports, have been given a major boost by a just concluded seven-day mission to China and Hong Kong led by Secretary of Commerce Ronald H. Brown.

The Presidential Business Development Mission to China was the first Cabinet-level visit since the Clinton Administration renewed "most favored nation" trade status for China in May and decoupled trade relations from China's human rights policies (C&EN, May 30, page 7). Brown was accompanied by two dozen chief executive officers from major U.S. corporations, including Atlantic Richfield, Chrysler, Eastman Kodak, Fluor Corp., Foster Wheeler, TRW, and Westinghouse.

Delegation members met senior Chinese officials to advance cooperation on bilateral issues, such as protection of intellectual property and market access. The CEOs also discussed business agreements with the Chinese and signed contracts totaling several billion dollars.

A central focus was signing of a "historic framework agreement" by Brown and Wu Yi, China's Minister of Foreign Trade & Economic Cooperation, who cochair the U.S.-China Joint Commission on Commerce & Trade (JCCT). Under the agreement, JCCT bilateral working groups will foster cooperation in several sectors, including chemicals, electronics, electric power, telecommunications, aviation, automotive machinery, and services. Similar cooperation is envisioned in envi-

Sales brisk for ACS Publications on Disc

Susan Barclay of ACS Publications Division displays a page with a full-color illustration from the CD-ROM version of *Biochemistry*, one of two journals in the just-released ACS Publications on Disc series. A month after the first discs were shipped, sales are brisk for both *Biochemistry* and the *Journal of the American Chemical Society*, says Anthony Durniak, head of ACS Special Publications. "Judging from initial interest in these two CD-ROM journals, we expect to expand the series to include many of the 24 ACS journals," he says. Unlike many text-only or bibliographic CD-ROMs, the ACS discs deliver complete journal pages, including typeset text, chemical equations, and all illustrations. Sophisticated graphics allow users to view entire articles on screen or to print them in black and white or color on their printers. *Biochemistry* is distributed on disc every two months, and *JACS*, every three months. The discs include the complete text and graphics of issues in that period, as well as cumulative indexes and text for that year. One disc user, professor of chemistry David E. Bergbreiter of Texas A&M University, says the "very fast search feature" speeds up literature searches. Readers can search by author or topic, for key words in the title or abstract, or in a combination of categories. The discs give "very high quality prints," he adds, and are "better archival forms than journals, because you can store 10 years' worth of journals in a few inches of shelf space."

C&EN staff photo

CD-ROM subscriptions, available in Windows or Macintosh versions, can be ordered alone or with a subscription to the printed journal. Order information may be obtained from Barclay at (202) 872-6219.

Madeleine Jacobs

Fertilizers, organic chemicals, and plastics top U.S. chemical exports to China

$ Millions	1993 Exports	1993 Imports	January–May 1994 Exports	January–May 1994 Imports
Fertilizers	$293	$ 0	$229	$ 0
Organic chemicals	204	127	91	70
Primary plastics	168	16	72	3
Dyeing & coloring materials	29	39	16	16
Pharmaceuticals	27	126	9	60
Inorganic chemicals	25	134	19	84
Nonprimary plastics	22	6	7	3
Oils, perfumes & cleansing products	21	35	9	14
Other chemical materials & products	51	92	24	51
TOTAL CHEMICAL TRADE	$840	$575	$476	$301

Source: Department of Commerce

ronmental and health care technologies. "These all are areas that meet China's development priorities and in which U.S. business excels," Brown points out.

Fred Siesseger, director of the chemicals, pharmaceuticals, and biotechnology division at the Commerce Department, tells C&EN that efforts in the chemicals sector served as a model for organizing working groups in other sectors. The chemical group is led on the U.S. side by his office and on the Chinese side by the Ministry of Chemical Industry.

The chemical group's activities will embrace two areas, Siesseger notes: commercial issues—both obstacles and opportunities for U.S. trade and investment in China—and promotion of U.S. exports to China.

One of the commercial issues to be addressed at the first meeting of the chemical group, planned for later this month in Beijing, involves "very serious problems created by China's new environmental regulations," he says. "As currently drafted, they could disrupt almost $1 billion in chemical imports from the U.S." The group also will discuss intellectual property protection and market access in China as well as "market transparency"—that is, development of a business information center to supply information on trade and investment opportunities for U.S. companies.

Discussions at the Beijing meeting also will focus on ways of promoting U.S. chemical exports, such as trade missions, conferences and seminars, and trade shows. Siesseger notes that these efforts will build on cooperation already developed with the Chinese by his office, including a successful one-week trade mission to China last month by U.S. firms that make water treatment chemicals and equipment, as well as a coatings technology mission last year.

Next week, a delegation of nine leading U.S. suppliers of plastics additives plans to visit Shanghai and Beijing. Two-day technical seminars will be presented for some 150 to 200 Chinese industry officials at each city. A mission on plastics is scheduled for November, and one on food-processing chemicals for next spring. And the Beijing meeting will look at organizing a mission on pollution control for chemical industry.

So much is planned because "China is the fastest growing chemical market in the world," Siesseger stresses. "I think it's the linchpin for trade and investment in Asia. And many companies are starting to realize that if they want to be global players, they have to participate in the China market."

Richard Seltzer

NIH spurs research on novel AIDS therapies

A new multi-million-dollar program to push development of innovative therapies to fight infection by the human immunodeficiency virus (HIV), the cause of AIDS, has been launched by the National Institute of Allergy & Infectious Diseases (NIAID), a unit of the National Institutes of Health, Bethesda, Md.

NIAID's Strategic Program for Innovative Research on AIDS Treatment (SPIRAT) will support six research teams for four years, each team consisting of three or more investigators from at least three U.S. institutions. NIAID has awarded a total of $6.2 million for the first year of the program, with similar support projected for subsequent years. The teams are to begin early studies in humans by the third year, at the latest.

SPIRAT "provides an important bridge between basic and clinical research and offers the potential for the development of effective, long-term treatments for HIV-infected people," says John Y. Killen, director of the NIAID Division of AIDS. "The state-of-the-art strategies proposed by the research groups are conceptually exciting and scientifically well grounded."

The program will support a variety of research:

- Philip D. Greenberg, a member of the Fred Hutchinson Cancer Research Center, Seattle, will use genetic manipulation to bolster the function of lymphocytes known as $CD8^+$ and $CD4^+$ T cells from HIV-infected individuals.
- Judy Lieberman, an assistant professor of medicine at Tufts University School of Medicine and a physician at the New England Medical Center, Boston, will use "adoptive immunotherapy," which combines immune cells with cytokines, to augment the immune system's capacity to eliminate HIV-infected cells.
- Thomas C. Merigan, a professor of medicine at Stanford University, will explore a similar adoptive immunotherapy technique that infuses immune cells from donors without HIV infection into their HIV-infected siblings.
- Gary J. Nabel, a principal investigator at the Howard Hughes Medical Institute, Ann Arbor, Mich., will investigate a gene therapy strategy for children that harnesses a defective HIV *rev* gene to attempt to prevent the virus from killing $CD4^+$ T cells.
- Flossie Wong-Staal, a professor of medicine and biology at the University of California, San Diego, will study a type of gene therapy that uses a gene for a ribozyme designed specifically to cleave and inactivate a portion of HIV's genetic material.
- David Weiner, an assistant professor of pathology and laboratory medicine at the University of Pennsylvania Medical Center, will explore DNA-based therapeutic vaccines, including methods to facilitate the effectiveness of DNA injection techniques.

NIAID also has renewed grants to 12 sites and added four new sites under its Community Programs for Clinical Research on AIDS (CPCRA). First-year funding for the 16 five-year awards totals $12 million. CPCRA, which began in 1989, offers HIV-infected patients the opportunity to participate in clinical trials of HIV therapies in community settings such as private practices, clinics, and health centers. With the four new sites, CPCRA will have units in 15 cities. More than 15,000 patients have enrolled in 23 trials.

Rudy Baum

New actions to prevent chemical accidents urged

Fundamental steps by federal, state, and local governments and industry to prevent chemical accidents—rather than programs "preoccupied with accident mitigation and emergency response"—are urged in an analysis of U.S. toxic chemical accidents issued last month by two consumer and environmental groups.

The 25-page report, "Accidents Do Happen," was prepared by the National Environmental Law Center (NELC), based in Boston, and the U.S. Public Interest Research Group (PIRG), based in Washington, D.C. The report examines chemical accidents from 1988 to 1992 using data from the Environmental Protection Agency's Emergency Response Notification System (ERNS)—based primarily on initial telephone reports of accidents to authorities. ERNS is the largest and most comprehensive database on U.S. chemical accident notifications and covers both transportation and plant accidents.

The study includes incidents involving some 800 toxic and hazardous chemicals regulated under federal laws. It excludes oil, gasoline, and other petroleum product spills—which constitute 52% of ERNS notifications.

The report finds that "toxic chemical accidents are a common, ongoing problem with potential for catastrophe." Almost 34,600 incidents were reported to ERNS from 1988 to 1992. About 6% resulted in deaths, injuries, or evacuations.

ERNS data show release of more than 680 million lb of toxic chemicals into the environment from these accidents. However, the report says, even this large number "is a gross underestimate." A third of ERNS notifications give no estimate of quantities, and many accidental spills are not reported. Almost 10% of reported incidents involved releases of more than 10,000 lb.

About 47% of the accidents emitted toxic chemicals to land, 38% to air, and 15% to surface waters. And in data not in the report, coauthors Joel A. Tickner and Hillel Gray of NELC find 75% of the releases occurred at plants and other fixed facilities, 8% on roads, 5% on railroads, 3% from pipelines, and 8% from other, or unclassified, sources.

Almost two thirds of the accidents involved one of 15 chemicals. Heading the list with almost 3,600 accidents are polychlorinated biphenyls.

More than half the accidents occurred in 10 states, led by California and Texas, with Louisiana third. Just 63 of the U.S.'s 3,181 counties account for more than 40% of the incidents. Ranking first is Harris County, Texas, which includes Houston. It is followed by Los Angeles County, California; Jefferson County on the Texas Gulf Coast; Calcasieu County in the Lake Charles, La., area; and San Diego County, California.

Environmental groups view the report as "a wakeup call" for political and industry leaders, Tickner tells C&EN. The study notes that chemical safety programs and two federal agencies overseeing them—EPA and the Occupational Safety & Health Administration—"are more geared to conventional accident mitigation and add-on safety systems than fundamental prevention."

A better approach, the report stresses, is to prevent accidents through the relatively new principle of "inherent safety" or "primary accident prevention"—redesigning industrial processes "to be inherently more safe and involve less toxic materials." NELC and PIRG urge federal, state, and local agencies and industry to make "aggressive efforts to promote inherent safety," and to set numerical goals for reducing chemical accidents. They call on federal and state agencies to greatly improve public access to data on accidents, toxics use, and potential "worst case" accident hazards.

A key recommendation—also backed by the Oil, Chemical & Atomic Workers International Union—is that the Administration start up promptly, with adequate funding, the Chemical Safety & Hazard Investigation Board. Established by the Clean Air Act Amendments of 1990, this five-member board is charged with investigating chemical accidents and conducting research on chemical safety and accident prevention.

However, four years after its establishment, the board is still not functioning. A chairman and three members have just been named and await Senate confirmation (C&EN, Aug. 1, page 25). It's expected that a fifth member, with industry background, will be announced soon. But Congress is so far holding back on funding, originally projected at about $5 million a year, with a staff of 30. NELC and PIRG believe this independent board, reporting directly to the President, could be "a motivating force in the shift toward inherent safety."

Responses to the report from chemical industry and EPA generally take a positive tone. Don Helin, director of safety, health, and operations for the Chemical Manufacturers Association, notes that the chemical sector is consistently among the three safest U.S. industries, but "we are always trying to improve our performance." Craig Matthiessen, director of the chemical accident prevention staff at EPA, says, "We're very supportive of the recommendations in the report. It's what we're trying to do."

Richard Seltzer

Two states have 27% of toxic chemical accidents . . .

	Accidents 1988–92	
	Total	With injuries[a]
California	4,820	409
Texas	4,532	176
Louisiana	2,505	60
Pennsylvania	1,395	78
Ohio	1,269	84
Kentucky	1,166	36
Illinois	1,085	64
Florida	905	84
Michigan	869	50
New Jersey	857	64
Others	15,172	1,081
TOTAL[b]	**34,575**	**2,186**

. . . and PCBs lead list of chemicals released

	Accidents 1988–92	
	Total	With injuries[a]
Polychlorinated biphenyls	3,586	34
Ammonia, anhydrous	3,333	389
Sulfuric acid	2,387	130
Chlorine	2,099	409
Hydrochloric acid	1,504	143
Ethylene glycol	1,470	18
Sulfur dioxide	1,310	86
Radioactive materials	1,073	30
Benzene	1,048	14
Hydrogen sulfide	939	49
TOTAL[c]	**18,749**	**1,302**

a Accidents resulting in immediately reported deaths, injuries, or evacuations but excluding chronic health and environmental effects. b For all 50 states, Puerto Rico, District of Columbia, Virgin Islands, and Guam. c For top 10 chemicals released (but many accident notification forms do not properly identify all chemicals released). **Source:** Emergency Response Notification System database (1988–92), compiled by the National Environmental Law Center and U.S. Public Interest Research Group

Chemists Ponder Reforms To Organic Chemistry Curriculum

■ ***Survey suggests it's time to 'prune' outmoded topics, but is there room to teach environmentally benign chemical synthesis?***

208 ACS National Meeting
Washington, D.C.

Deborah L. Illman,
C&EN West Coast News Bureau

Like miners tunneling their way through a mountain beginning from different sides, the question is, will efforts to reform the organic chemistry curriculum meet up, or will they pass each other by?

The content of the organic chemistry curriculum was discussed in two separate symposia at the ACS national meeting in Washington, D.C. One, entitled "Examining the Organic Chemistry Lecture Course," was sponsored by the Division of Chemical Education. The other was a part of the wide-ranging "Design for the Environment" symposium sponsored by the Division of Environmental Chemistry. There's evidence to suggest that the two groups of reformers may not be on convergent paths.

"Environmentally Benign Syntheses and Processes in the Chemistry Curriculum" was organized by Paul T. Anastas and Tracy C. Williamson, of the Environmental Protection Agency, and Margaret A. Cavanaugh, a program director in the chemistry division of the National Science Foundation.

Anastas and Williamson say the changing nature of chemical manufacturing in the 1990s has created the need to address curriculum reform. They point out that synthetic chemists are the key practitioners in identifying, developing, and implementing actual source reduction technologies. Those same chemists are now being challenged to incorporate pollution prevention into everyday practices.

"When designing the synthesis of a chemical substance," according to Anastas and Williamson, "chemists must now consider the hazards associated with starting materials, solvents, catalysts, coproducts, by-products, or any other chemicals used in or formed from all reactions of a particular synthetic scheme."

The problem, Anastas says, is that pollution prevention principles generally have not been incorporated into the chemistry curriculum. As a result, EPA has launched what it calls the Benign by Design Chemistry Curriculum Program. The program is funding efforts at the National Pollution Prevention Center at the University of Michigan, Ann Arbor, and the Emission Reduction Research Center at the New Jersey Institute of Technology, Newark, to develop general education materials that do incorporate such principles.

But it doesn't seem that an environmental sensibility has yet made its way into the mainstream organic chemistry community. "Green" chemistry was not a focus of attention in the chemical education symposium.

Nevertheless, rumblings of change were stirring. In his talk titled "Introductory Organic Chemistry—A Basket Case!?" Samuel S. Stradling, of the chemistry department at St. Lawrence University, Canton, N.Y., maintained that "the content and teaching of intro-

Faculty would keep most organic chemistry topics . . .

- **Alkanes**
  - Combustion
  - Free radical halogenation
- **Alkenes**
  - Addition, hydrogenation
  - Hydration, oxidation
  - Free radical reaction
- **Alkyl halides**
  - Substitution, elimination
- **Alcohols**
  - Alkoxide formation
  - Oxidation, conversion to HX
  - Dehydration
- **Aldehydes and ketones**
  - Addition of water, alcohols, amines
  - Reduction, Wittig reaction
- **Alkynes**
  - Reduction, addition of HX
- **Aromatics**
  - Halogenation, Friedel-Crafts
  - Nitration, sulfonation, oxidation
  - Addition to naphthalene
- **Dienes**
  - Diels-Alder
  - Addition of halogens and halides
- **Carboxylic acids and derivatives**
  - Reduction, Grignard
  - Hydrolysis, acyl halides
- **Enols**
  - Aldol, crossed aldol
  - Claisen, Dieckman, Michael reactions
  - Malonic ester synthesis
- **Amines**
  - Alkylation, acidity
  - Hofmann elimination
  - Aromatic amines
  - Aryl diazoniums
- **Organometallics**
  - Grignard, alkyllithiums
- **Others**
  - Carbohydrates, amino acids

. . . and would drop precious few

- Biochemical reactions
- Esoteric name reactions
- Concerted reactions except Diels-Alder
- Advanced spectroscopy
- Reactions of sulfur compounds
- Functional group tests

Note: Based on a survey by Marco Pagnotta, Columbia University, and colleagues of about 200 schools nationwide, which asked organic chemistry professors to choose topics that should be excluded from the curriculum.

ductory organic chemistry has deservedly been under siege for some time. Nonetheless, change has been slow to occur." In his classes, Stradling uses case studies on topics such as taxol, the ozone layer, and aspirin to enrich the presentation of introductory organic chemistry.

Results of a new nationwide survey of chemistry faculty about topics that should be retained in organic chemistry textbooks and courses that should be taken out were presented by Marco Pagnotta, of Barnard College, Columbia University, New York City. Pagnotta conducted the study with John P. Wasacz, of Manhattan College, Riverdale, N.Y., and Leslie A. Hull, of Union College, Schenectady, N.Y.

Pagnotta and his coworkers set out to explore whether there is a consensus among instructors of organic chemistry on course content. A survey sent to about 200 schools asked respondents to choose from a list of specific topics those they thought could be omitted from either the lecture, the text, or both. Responses were obtained from 56 of 99 surveys sent to primarily undergraduate institutions, as well as from 44 of 102 surveys sent to schools with graduate programs.

Respondents were quicker to cut items from the course syllabus than from textbooks, thereby keeping a wide range of resource material available. Pagnotta says the topics receiving the strongest vote of confidence were stereochemistry and substitution, elimination, and addition reactions. Topics that could be cut included biochemical reactions, esoteric reactions, advanced spectroscopy, reactions of sulfur compounds, and functional group tests.

Enrollments in organic chemistry are increasing at 72% of responding institutions. But declared chemistry majors are in the minority: 60% of students enrolled in organic chemistry classes are biology majors, and only 12% are chemistry majors. Pagnotta concludes that most students take organic chemistry to satisfy requirements of other departments.

Some symposium presenters tell C&EN that the pedagogic value of traditional topics outweighs environmental considerations, and therefore, conventional topics should be kept despite the fact they may not be considered environmentally benign. And some argue that the curriculum is just too full to address principles of green chemistry.

If the organic chemistry curriculum is already overfull, and if faculty place priority on traditional reactions and topics, can there be any common ground with those who would modernize the curriculum to be "benign by design"? Anastas believes "there is an increasing number who say yes."

Adding environmentally benign chemistry "is not about putting another layer of material on top of the chemistry curriculum," asserts Anastas. "It is about recognizing that some of the existing synthetic methodologies and some of those yet to be discovered are more environmentally benign than others."

Frank Vellaccio, vice president of academic affairs at the College of the Holy Cross, Worcester, Mass., contends it is time to question whether what is being taught in introductory chemistry contributes to the common good. He suggests that social values and environmental ethics are valid motivating factors for including material in the introductory curriculum.

Francis A. Carey, a chemistry professor at the University of Virginia, Charlottesville, points to some good reasons for including "benign by design" in organic courses. "If chemists don't demonstrate that the chemical community is committed to good stewardship, then who will?" he asks.

Carey further notes that the timing is right: Students these days tend to be environmentally conscious, and curriculum material targeting pollution prevention introduces important ideas that connect chemistry to economic and environmental concerns.

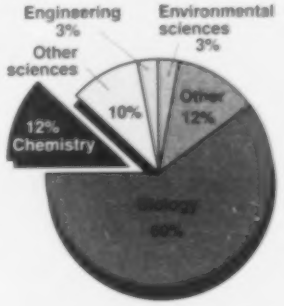
Meanwhile, the National Pollution Prevention Center (NPPC) at the University of Michigan, Ann Arbor, is planning to launch a program this year aimed at developing laboratory experiments, text supplements, and a compendium of resource materials for organic and inorganic chemistry courses relating to the design of environmentally benign chemical synthesis.

NPPC manager Gregory A. Keoleian says that a set of materials for chemical engineering has been under development for some time and will be available this month. Some of the education materials include problem sets, case studies, and videotapes, available at nominal cost, that can be used in chemical engineering courses.

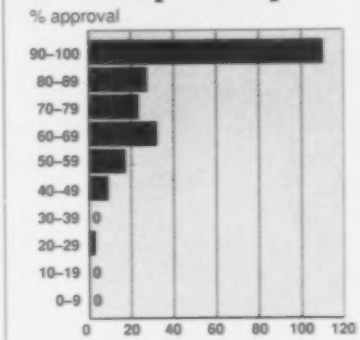
Researchers at the Emission Reduction Research Center have been working for some time to develop curriculum materials for engineering, social sciences, and humanities that deal with pollution prevention. For the past year, the center has been working with an industrial partner to develop training experiences for industrial chemists in pollution prevention. Center director Daniel J. Watts says their approach involves raising the consciousness of chemists about manufacturing processes and the pollution problems associated with them.

EPA's Williamson believes industry will be a driving force for incorporating green chemistry into the curriculum, because otherwise, companies will have to devote time and resources to retraining personnel. Others believe that graduate research on environmentally benign synthesis will create a "trickle-down" effect, eventually showing up in the undergraduate curriculum. □

Chemistry majors are a minority in organic classes



Organic chemistry profs would keep most topics



Note: Results of a survey of organic chemistry faculty on which of 237 topics should be retained in the organic chemistry curriculum.